

# DISCOVERY

## To Cite:

Alagbe JO, Agubosi OCP, Oluwafemi RA. Effects of dietary supplementation of *Prosopis africana* (African mesquite) essential oil on the growth performance, nutrient retention and oxidative stress indices of broiler chicken. *Discovery* 2023; 59: e87d1283

## Author Affiliation:

Department of Animal Science, University of Abuja, Gwagwalada, Nigeria

## \*Corresponding Author

Department of Animal Science, University of Abuja, Gwagwalada, Nigeria  
Email: dralagbe@outlook.com

## Peer-Review History

Received: 07 May 2023

Reviewed & Revised: 11/May/2023 to 15/June/2023

Accepted: 19 June 2023

Published: July 2023

## Peer-Review Model

External peer-review was done through double-blind method.

Discovery

pISSN 2278-5469; eISSN 2278-5450



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# Effects of dietary supplementation of *Prosopis africana* (African mesquite) essential oil on the growth performance, nutrient retention and oxidative stress indices of broiler chicken

Alagbe JO\*, Agubosi OCP, Oluwafemi RA

## ABSTRACT

This research was undertaken to evaluate the effects of dietary supplementation of *Prosopis africana* essential oil on the growth performance, nutrient retention and oxidative stress indices of broiler chickens. A total of 540 one- day-old (Arbo acre) broiler chicks were randomly assigned to six treatment groups with six replicates of fifteen birds each. Experimental diet was adequate in all nutrients according to NRC, (1994) recommendation. Dietary treatments were as follows: Treatment 1 (T<sub>1</sub>): Basal diet with no *Prosopis africana* oil (PAOs); T<sub>2</sub>: Basal diet plus neomycin at 2.5 g/kg while T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub> and T<sub>6</sub> were fed basal diet supplemented with 200 mg, 400 mg, 600 mg and 800 mg/kg PAOs respectively. Improvements for body weight gain and feed conversion ratio ( $P<0.05$ ) were observed in birds fed PAOs compared to the other treatments. Mortality rate was highest in T<sub>1</sub> (5.33 %) followed by T<sub>2</sub> (3.02 %) and T<sub>3</sub> (1.00 %) ( $P<0.05$ ). Dressing percentage and weights of organs were significantly ( $P<0.05$ ) influenced by the treatments except the weights of kidney, spleen, pancreas and busra ( $P> 0.05$ ). Dry matter and crude protein digestibility were highest in T<sub>3</sub> through T<sub>6</sub>, intermediate in T<sub>2</sub> and lowest in T<sub>1</sub> ( $P<0.05$ ). Malondialdehyde, catalase, glutathione peroxidase, reduced glutathione and superoxide dismutase were significantly ( $P<0.05$ ) different among the treatments. *Conclusion:* It was concluded that the dietary supplementation of PAOs up to 800 mg/kg in broiler chickens could arouse its appetite translating to higher weight gain, increased secretion of enzymes in the gastro intestinal tract as well as reduction of free radicals.

**Keywords:** Broilers, Phytochemicals, Performance, Oxidative stress, *Prosopis africana*

## 1. INTRODUCTION

Phytogenics are substances that come from plants such as spices, herbs, essential oils and other plant extracts. They have been utilized for countless years for both traditional uses and for their unique abilities as natural treatments (Steiner, 2010). Among other biological actions, phytogenic substances have antioxidant, antibacterial, antifungal, antiviral, hepato-protective, immune-stimulatory amongst others (Alagbe, 2022; Singh et al., 2021). Following the 2009 European Union ban on antimicrobial growth promoters, numerous studies were conducted to investigate possible replacements. Using essential oils have been adopted as one of the potential alternatives to antibiotics (Musa et al., 2020; Axel, 2018).

Essential oils are volatile oils extracted from plants using steam or hydro distillation as the distillation method (Marc, 2010). They contain plant – derived chemicals with a sophisticated chemical make-up from leaves, stems, bark, seeds, flowers and other plant parts essential oils can be extracted (Alagbe et al., 2023; Axel, 2018). It is thought that they hold knowledge and specific instructions for the conduct and survival of the plants (Steiner, 2010; Benzoni and Guyonvarch, 2012). Additionally, the harvest season, climatic conditions and cultivar within a plant variety – particularly for *Prosopis africana* oil have an impact on the composition of essential oils (Alagbe, 2022; Sandra, 2018).

The essential oil of *Prosopis africana* is packed with volatile and fragrant substances. Prosogerin is one of the oil's major bioactive components which has been discovered to play a part in processes such as stimulation of digestion, antimicrobial properties, antioxidant activity and stimulation of feed intake (Sandra, 2018; Klis and Vinyeta, 2013). In broilers, *in vivo* antimicrobial efficacy of *Prosopis africana* oil on *Escherichia coli*, *Staphylococcus spp*, *Streptococcus spp* and other pathogenic organisms when supplemented at 300 mg/kg was demonstrated (Shittu and Alagbe, 2010).

Furthermore, in an experiment carried out by Alagbe et al., (2022), dietary inclusion of *Prosopis africana* oil (PROs) at 400 mg/kg for broilers stimulate digestive process, efficient feed utilization and balanced gut micro flora. Field trials have shown the great benefit of PROs application in attenuating inflammatory processes in the intestine by blocking the pro-inflammatory transcription factor NF- $\kappa$ B and removing free radicals in birds when included in the diet at 100 mg/kg. It has been reported that essential oils can act as immune suppressors or immune stimulators to stimulate the immune system through the host (Steiner, 2010; Alagbe, 2017).

They can also the levels of plasma lipid peroxidation and malondialdehyde it can help to lessen excessive oxidative stress (Marc, 2010; Luis, 2012). Reactive oxygen species play a role in a variety of diseases, including chronic inflammation; hence there is a close relationship between antioxidant and anti-inflammatory function (Adewale et al., 2021). *Prosopis africana* oil has a lot of promise and it's important to set up a foundation for adding it to broiler's diet. The purpose of this experiment was to ascertain how well broiler chickens given *Prosopis africana* essential oil performed in terms of growth, carcass characteristics, nutrient digestibility and oxidative stress markers.

## 2. MATERIALS AND METHODS

### Location of the experiment, ethical approval and *Prosopis africana* essential oil extraction

The experiment was conducted at the University of Abuja Teaching and Research Farm, Department of Animal Science along Airport Road in Gwagwalada which is positioned between latitudes 8°57' and 8°55'N and longitudes 7°05' and 7°06'E (NPC, 2006). The department of Animal Science at the University of Abuja's research ethics committee accepted the protocol for the study, which was conducted in accordance with its specifications and rules. The *Prosopis africana* seeds utilized in this study was purchased from a local market in Gwagwalada in April, 2021. With a voucher number of ANS/203ER/008, the seeds were identified and verified at the Department of Biological Sciences herbarium, University of Abuja, Nigeria.

*Prosopis africana* oil was obtained using the steam-distillation method, which also calls for the use of a digital scale, a round-bottom flask, a heating mantle made of glass fiber, a measuring cylinder and a separatory funnel. 150 g of ground *Prosopis* seed and 250 mL of distilled water were put into a flask with a circular bottom. The resulting mixture was transferred to a glass yarn heating mantle and heated to an internal temperature of 80 degree Celsius before the condenser was placed on top of the flask with a circular bottom. Fifteen minutes of forced boiling is given to the combination, after which the distillate is collected in a beaker until no more oil drops are present. The distillate was introduced to the separatory funnel in order to obtain *Prosopis africana* essential oil.

### Animal care (diets, housing and arrangements)

540 mixed-sex 1-day-old broiler chicks (Arbo Acres), obtained from a well-known commercial hatchery in Ogun State, Nigeria, were divided into six treatments, each with six replicates of fifteen birds. Galvanized hand feeders and automatic nipple drinkers were installed in a galvanized battery cage that measured (100 cm × 75 cm × 50 cm) (length depth height) in semi-open pens. Chicks

were given anti-stress (glucose plus water) at a rate of 2 grams of glucose to 10 liters of water after being weighed upon arrival to ascertain their average starting body weight.

In this investigation, an entirely random experimental design was adopted. Diets were compounded based on NRC, (1994) nutritional needs for broilers, which are in (Table 2). The experimental diet provides 23.30% crude protein (CP), 21.40% CP and metabolizable energy content (ME) of 2991.5 Kcal/kg and 3108.1 Kcal/kg respectively at the starter phase (1-28 days) and finisher phase (29-56 days). For the duration of the experiment's eight-week run, all birds had free access to food and water.

The following is a representation of the experimental arrangement:

Treatment one (T1): Basal diet with no *Prosopis africana* oil (PAOs)

Treatment two (T2): Basal diet plus 2.5 g/kg of Neomycin

Treatment three (T3): Basal diet plus 200 mg/kg *Prosopis africana* oil

Treatment four (T4): Basal diet plus 400 mg/kg *Prosopis africana* oil

Treatment five (T5): Basal diet plus 600 mg/kg *Prosopis africana* oil

Treatment six (T6): Basal diet plus 800 mg/kg *Prosopis africana* oil

## Variables collected

### Performance traits

The difference between the feed offered and rejected was used to calculate the amount of feed consumed. The ratio of average feed intake to average body weight growth was used to figure out the feed conversion ratio or the amount of feed required creating one unit of gain. The difference between the end body weight and the starting body weight was used to compute weight gain. Weight gain for each treatment divided by the number of experimental days was used to calculate the average daily body weight. The number of deceased birds divided by the total number of birds multiply by 100 was used to compute the mortality percentages all through the experimental period.

### Carcass quality evaluation

12 birds from each treatment were randomly chosen at the close of the experiment to be evaluated for carcass quality. In order to avoid contamination and fly invasion, carcass examination was done in a clean, fly-free environment. Prior to slaughter, the chosen birds were weighted and feed-starved for a twelve-hour period. By cutting the jugular vein, putting the bird into hot water and manually plucking the feathers, the birds were humanely killed. The heart, pancreas, kidney, lungs and proventriculus were carefully removed from the carcass. Each organ was then weighed separately and documented.

The ratio of carcass weight to slaughter weight, multiplied by 100, was used to compute the dressing %. The eviscerated carcass's breast, wings, thighs with drumsticks and backside were all removed, weighed and the percentage of the remaining weights of each was calculated by dividing the total weight by the slaughter weight and multiplying the result by 100.

### Nutrient retention trial

At the conclusion of the study (day 56), twelve birds were randomly chosen from the treatment and placed in individual metabolic cages (measuring 25 cm × 20 cm × 30 cm in length, depth and height) with automatic nipple drinkers and galvanized manual feeders. Birds were acclimated and fed a known amount of food on the first day of the trial. Droppings were collected, weighed and air dried daily for each replicate. Fecal excretions were bulked up for each replicate on the final day of the study and delivered to the lab for additional analysis.

Proximate analysis of fecal droppings were carried out using near infra-red spectroscopy (NIRS™ DA1600) with specifications: dimension (200 × 130 × 100 mm) (w×d×h), optical band width (9.44± 0.76 nm), wave length (1400 - 2000 nm), spectral resolution (0.9 nm /data point), detector (206 pixel in GaAs diode array), absorbance range (up to 3 AU) and wavelength precision (< 0.08 nm). The data were expressed as follows:

Nutrient retention (% DM) is equal to the difference between intake and output in the form of excretion divided by intake multiplied by 100.

### Oxidative stress investigation

Samples of liver were harvested from 12 birds per treatment (from birds used for carcass investigation). Liver samples were immersed into potassium solution and subjected to test using NEXRO kit (Model 81-09A, India). The kit has the following components; (DNPH solution, hematoxylin, wash buffer, biotinylated secondary antibody and antigen retrieval buffer). Oxidative

detection of glutathione peroxidase, catalase, reduced glutathione, superoxide dismutase and malondialdehyde were measured on the display or output unit.

### Statistical investigation

Using Statistical Package for Social Sciences [SPSS (18.0)], one-way analysis of variance was performed on all data and Duncan multiple range tests were used to identify significant means. If  $P < 0.05$ , significance was deemed to exist.

**Table 1** Gross composition of experimental diets

| Components          | Starters phase<br>(0-28 days) | Finishers phase<br>(29-56 days) |
|---------------------|-------------------------------|---------------------------------|
| Maize               | 53.50                         | 59.00                           |
| Wheat offal         | 2.00                          | 5.00                            |
| Soya bean meal      | 30.00                         | 24.00                           |
| Groundnut cake      | 7.00                          | 5.00                            |
| Fish meal (65 %)    | 2.00                          | 1.00                            |
| Limestone           | 1.50                          | 2.00                            |
| Bone meal           | 3.00                          | 4.00                            |
| Lysine              | 0.20                          | 0.20                            |
| Methionine          | 0.20                          | 0.20                            |
| *Premix             | 0.25                          | 0.25                            |
| Salt                | 0.30                          | 0.35                            |
| ***Toxin binder     | 0.10                          | 0.10                            |
| Total               | 100.0                         | 100.0                           |
| Determined analysis |                               |                                 |
| Crude protein (%)   | 23.30                         | 21.40                           |
| Crude fibre (%)     | 4.18                          | 5.01                            |
| Ether extract (%)   | 4.03                          | 4.47                            |
| Calcium (%)         | 1.50                          | 1.80                            |
| Phosphorus (%)      | 0.58                          | 0.66                            |
| Energy (kcal/Kg)    | 2991.5                        | 3108.1                          |

\*Premix supplied per kg diet: - vit A, 14,000 IU; vit E, 5mg; vit D3, 3000 IU; vit K, 3mg; vit B2, 5.5mg; Niacin, 25mg; vit B12, 16mg; choline chloride, 120mg; Mn, 5.2mg; Zn, 25mg; Cu, 2.6g; folic acid, 2mg; Fe, 5g; pantothenic acid, 10mg; biotin, 30.5g; Antioxidant, 56mg (starter's mash)

\*\*Premix supplied per kg diet: - vit A, 9,000 IU; vit E, 10mg; vit D3, 1500 IU; vit K, 3.8mg; vit B2, 10 mg; Niacin, 15mg; vit B12, 10mg; choline chloride, 250mg; Mn, 5.0mg; Zn, 56mg; Cu, 1.6g; folic acid, 2.8mg; Fe, 5.1g; pantothenic acid, 10mg; biotin, 30.5g; antioxidant, 56mg (finisher's mash)

\*\*\* Toxin binder composition per Kilogram: Mannan Oligo Saccharide (MOS) (50grm), Activated charcoal 20 grams, activated charcoal 20 grams, ammonium formate 20 grams, citric acid 10 grams, calcium propionate 20 grams, sodium bentonite 20 grams, hydrated sodium calcium aluminosilicate 725 grams.

## 3. RESULT AND DISCUSSION

### Performance of broiler chickens fed diet containing *Prosopis africana* essential oil (PAOs)

Growth performance of broiler chickens fed *Prosopis africana* oil (Table 2) revealed that the initial body weight, final body weight, body weight gain, average daily weight gain, total feed intake, average daily feed intake, feed conversion ratio and mortality varied between 43.29 - 44.20 grams, 1825.1 - 3024.6 grams, 1029.6 - 1775.6 grams, 18.39 - 31.71 grams, 4307.2 - 4425.6 grams, 76.91 - 79.03 grams, 1.46 - 2.40 and 1.00 - 8.33 percent respectively. The treatments considerably differed ( $P < 0.05$ ) in average daily weight gain (ADWW), feed conversion ratio and % mortality.

Treatment 4 (T4) through T6 have the highest ADWW followed by T3 and lowest in T1 and T2 ( $P < 0.05$ ). Conversely, mortality percentages were maximum in T1 compared to the other groups ( $P < 0.05$ ). Average daily feed intake values were not statically influenced ( $P > 0.05$ ) by the treatments, though it increased slightly through treatment 1 to 6 but not at a significant rate. The experimental diets were formulated to meet the nutrient requirements of broiler chicks as recommended by NRC, (1994). In this

study, the presence of phytochemicals or secondary metabolites in *Prosopis africana* oil could cause beneficial effects on their performance and health status of broiler chickens.

In this study, the improved body weight gain (ADW) and feed conversion ratio (FCR) of the experimental birds fed *Prosopis africana* oil supplemented diets could be due to the activities of the constituents of these phytochemicals (Oluwafemi et al., 2021; Shittu et al., 2022). Among the treatments, birds fed higher doses of PAOs (300 and 400 mg/kg) gained more weight than those on lower dose (100 and 200 mg/kg), implying that higher dose enhanced feed utilization better than the other treatments. The multiple biological activities of phytochemicals could have contributed to the improved BWg and FCR recorded in this group of birds (Alagbe et al., 2023; Singh et al., 2021).

Similar findings were made by Hafeez et al., (2009), who showed that matrix encapsulation of essential oils with active ingredients like thymol and limonene at the dosage of 100 mg/kg feed improved performance and apparent ileal digestibility of nutrients in broiler chickens compared with control. In addition, broiler chicks fed 0.5 mg/kg of anise seed oil with anethole as the active ingredient significantly increased body weight gain while having no impact on feed intake or feed conversion ratio, according to Soltan et al., (2008).

Furthermore, broiler chicks fed a higher level of anise seed oil (1.5 mg/kg) had lower growth performance in comparison to controls. This range of findings may indicate that phytochemical feed additives differ significantly in their chemical makeup depending on their constituents, climatic conditions, location and age of plants, dosage used, processing techniques and conditions during harvest or storage (Agubosi et al., 2021). The lowest weight increase was shown in the T1 group of birds, which did not receive any PAOs or antibiotics. This clearly shows that broilers cannot be raised in the tropics without the use of growth promoters, whether they are organic or synthetic.

According to reports, the PAOs increased the flavor and palatability of the feed, which led to an increase in voluntary feed intake and improved weight gain. This result contradicts Schone et al., (2006) findings, which showed that birds fed diets supplemented with caraway oil at 100 mg/kg consumed less feed overall. No mortality was observed in birds fed diets enriched with PAOs, suggesting that the oil may be able to stop the growth of pathogenic bacteria in the gastrointestinal tract. This outcome is consistent with the findings of previous study in 2021, who supplemented the feed of broiler chicks with *Irvingia gabonensis* and *Ocimum gratissimum* powder.

**Table 2** Performance of broiler chickens fed diet containing *Prosopis africana* essential oil

| Treatments | IBw<br>(g/bird) | FBw<br>(g/bird)     | BWg<br>(g/bird)     | ADWW<br>(g/bird)   | TFII (g) | ADFII<br>(g/bird) | FCR                | M (%)             |
|------------|-----------------|---------------------|---------------------|--------------------|----------|-------------------|--------------------|-------------------|
| T1         | 44.20           | 1825.1 <sup>d</sup> | 1029.6 <sup>c</sup> | 18.39 <sup>c</sup> | 4307.2   | 76.91             | 2.40 <sup>a</sup>  | 5.33 <sup>a</sup> |
| T2         | 44.10           | 2464.7 <sup>c</sup> | 1383.3 <sup>c</sup> | 24.70 <sup>c</sup> | 4419.0   | 78.91             | 1.80 <sup>b</sup>  | 3.02 <sup>b</sup> |
| T3         | 43.29           | 2744.1 <sup>b</sup> | 1614.1 <sup>b</sup> | 28.82 <sup>b</sup> | 4403.1   | 78.63             | 1.60 <sup>bc</sup> | 1.00 <sup>c</sup> |
| T4         | 44.08           | 2854.7 <sup>a</sup> | 1708.6 <sup>a</sup> | 30.51 <sup>a</sup> | 4400.9   | 78.59             | 1.54 <sup>c</sup>  | -                 |
| T5         | 44.10           | 2985.3 <sup>a</sup> | 1736.9 <sup>a</sup> | 31.02 <sup>a</sup> | 4421.1   | 78.95             | 1.50 <sup>c</sup>  | -                 |
| T6         | 43.93           | 3024.6 <sup>a</sup> | 1775.6 <sup>a</sup> | 31.71 <sup>a</sup> | 4425.6   | 79.03             | 1.46 <sup>c</sup>  | -                 |
| SEM        | 0.76            | 0.55                | 33.89               | 0.33               | 1.71     | 0.47              | 0.06               | -                 |
| P-value    | 0.01            | 0.18                | 0.29                | 0.11               | 0.44     | 0.02              | 0.001              | 0.93              |

Values in sections with various characters differ considerably ( $p < 0.05$ ); Initial Current Weight (IBw), Final Body weight (FBw) and gains in body weight (BWg) Average Daily Body Weight (ADWW), Average Daily Feed Consumption (ADFII), Feed Conversion Ratio (FCR), Mortality % (M), Standard Error of Mean (SEM), etc. Baseline diet + 0% *Prosopis africana* oil; Baseline diet + 2.0g/kg Neomycin; Baseline diet + 200 mg PAOs; Baseline diet + 400 mg PAOs; Baseline diet + 600 mg PAOs; Baseline diet + 800 mg PAOs.

### Carcass characteristics of broiler chickens fed diets with PAOs

The impact of *Prosopis africana* oil on the carcass characteristics of broiler chicken is in (Tables 3). Final live weight (FLw), dress weight (Dw), dressing percentage (D %) and mean weight of the head, legs, gizzard, liver, lungs, heart, thigh, breast, back, kidney, spleen, bursa and pancreas, respectively, varied from 1412.8 to 3200.4 grams, 967.8 to 2676.8 grams, 68.50 to 83.64% grams, 35.16 to 52.80 grams, 5.88 to 16.50 grams, 9.34 to 13.75 grams, 307.8 to 655.3 grams, 485.6 to 813.6 grams, 270.4 to 530.2 grams, 0.41 to 0.45 grams, 2.00 to 2.61 grams, 3.99 to 4.16 grams and 4.01 to 4.98 grams respectively.

Treatment 3 through T6 had the highest dressing % values, whereas middle in T2 and T1 had the lowest value ( $P < 0.05$ ). In comparison with the remaining treatments, T4, T5 and T6 had the maximum weight for drumstick, legs, liver, lungs, heart, thigh, breast and back ( $P < 0.05$ ). Treatments had no effect on the head, kidney, spleen, pancreas and bursa ( $P > 0.05$ ). The dressed weight



usually expressed as dressing percentage is an indication of meat value that could be obtained from an animal. When compared to the other treatments, birds fed PAOs had the highest dressing % ( $P < 0.05$ ). This implies that adding *Prosopis africana* essential oil supplementation at a dose of 100 to 400 mg/kg could effectively substitute in-feed antibiotics without lowering the dressing %.

Similar results were seen by previous study in 2014, which fed Hubbard broiler chickens garlic oil as a natural feed addition and observed enhanced carcass quality. The reduced organ weights, especially in the liver and kidney, show that the secondary metabolite concentrations of PAOs are not hazardous. According to Bamgbose et al., (2004), closhed weight and organ weight characteristics are actual symptoms or markers of the degree of anti-nutritional factor reduction. The absence of abnormal internal organ growth or atrophy suggests that the birds were able to tolerate PAOs. Since carcass features are a reflection of an animal's growth response, a decrease in dressed weight and dressing % is expected for (T1 without *Prosopis africana* oil or antibiotics) (Adewale et al., 2021).

Head, gizzard, kidney, pancreas, spleen, and bursa relative organ weights were not substantially ( $P > 0.05$ ) impacted by the treatments. As the supplemented amounts of PAOs rose across treatments, the relative weights of the lungs, heart, thigh, breast, drumstick and back considerably ( $P < 0.05$ ) increased. The relative weight of gizzard, thigh and lungs has been reported to increase in birds supplemented with cinnamon oil at 500 mg/kg feed, red pepper oil at 100 mg/kg, Savory oil at 50 mg/kg (Sarica et al., 2009) and oregano oil at 300 mg/kg (Krishan and Narang, 2014) while no changes were observed in birds fed rosemary oil (Attia et al., 2017); rosemary extract (Al-Hijazeen, 2021).

According to Rougiere and Carre, (2010), an increase in the relative weight of the gizzard in birds fed PAOs may lead to the swift production of pepsinogen and hydrochloric acid from the proventriculus, which will enhance feed degradation and reduce the entry of pathogenic bacteria into the digestive tract. Bile is produced by the liver, which is also connected to food metabolism (Alagbe et al., 2019). The generation of digestive enzymes is carried out by the pancreas, whereas the spleen actively participates in filtering potentially hazardous chemicals before they enter the bloodstream (Veen, 2005).

**Table 3** Effect of *Prosopis africana* oil on the retail cut parts and organ weights of broiler chicken

| Parameters   | T1                  | T2                  | T3                  | T4                  | T5                  | T6                  | SEM   | P-value |
|--------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|-------|---------|
| FLW (g)      | 1412.8 <sup>d</sup> | 1922.7 <sup>c</sup> | 2500.8 <sup>b</sup> | 2831.7 <sup>b</sup> | 3100.4 <sup>a</sup> | 3200.4 <sup>a</sup> | 34.70 | 0.07    |
| DW (g)       | 967.8 <sup>c</sup>  | 1481.1 <sup>b</sup> | 2000.6 <sup>a</sup> | 2291.8 <sup>a</sup> | 2510.9 <sup>a</sup> | 2676.8 <sup>a</sup> | 20.81 | 0.04    |
| DP (%)       | 68.50 <sup>c</sup>  | 77.03 <sup>b</sup>  | 80.00 <sup>a</sup>  | 81.01 <sup>a</sup>  | 81.00 <sup>a</sup>  | 83.64 <sup>a</sup>  | 5.02  | 0.22    |
| Head (g)     | 41.22               | 43.05               | 45.60               | 45.11               | 46.02               | 46.07               | 1.18  | 0.03    |
| D.stick (g)  | 123.7 <sup>c</sup>  | 166.1 <sup>b</sup>  | 178.6 <sup>ab</sup> | 191.7 <sup>a</sup>  | 196.5 <sup>a</sup>  | 197.9 <sup>a</sup>  | 3.03  | 0.08    |
| Leg (g)      | 50.28 <sup>c</sup>  | 78.44 <sup>ab</sup> | 82.10 <sup>a</sup>  | 83.00 <sup>a</sup>  | 85.80 <sup>a</sup>  | 86.88 <sup>a</sup>  | 1.35  | 0.05    |
| Gizzard (g)  | 68.67               | 69.05               | 70.94               | 71.60               | 71.49               | 71.04               | 1.20  | 0.25    |
| Liver (g)    | 35.16 <sup>c</sup>  | 41.50 <sup>ab</sup> | 50.47 <sup>a</sup>  | 52.39 <sup>a</sup>  | 52.01 <sup>a</sup>  | 52.80 <sup>a</sup>  | 1.12  | 0.41    |
| Lungs (g)    | 5.88 <sup>c</sup>   | 9.60 <sup>b</sup>   | 11.77 <sup>b</sup>  | 15.03 <sup>a</sup>  | 16.03 <sup>a</sup>  | 16.50 <sup>a</sup>  | 0.22  | 0.54    |
| Heart (g)    | 9.34 <sup>c</sup>   | 11.22 <sup>ab</sup> | 12.30 <sup>a</sup>  | 12.50 <sup>a</sup>  | 13.40 <sup>a</sup>  | 13.75 <sup>a</sup>  | 0.61  | 0.03    |
| Thigh (g)    | 307.8 <sup>c</sup>  | 501.0 <sup>b</sup>  | 558.5 <sup>b</sup>  | 611.2 <sup>a</sup>  | 642.5 <sup>a</sup>  | 655.3 <sup>a</sup>  | 9.45  | 0.48    |
| Breast (g)   | 485.6 <sup>d</sup>  | 590.3 <sup>c</sup>  | 730.5 <sup>b</sup>  | 768.3 <sup>b</sup>  | 800.2 <sup>a</sup>  | 813.6 <sup>a</sup>  | 6.33  | 0.02    |
| Back (g)     | 270.4 <sup>c</sup>  | 388.5 <sup>b</sup>  | 456.7 <sup>ab</sup> | 500.6 <sup>a</sup>  | 516.7 <sup>a</sup>  | 530.2 <sup>a</sup>  | 5.90  | 0.03    |
| Kidney (g)   | 0.41                | 0.45                | 0.43                | 0.45                | 0.44                | 0.45                | 0.03  | 0.01    |
| Spleen (g)   | 2.00                | 2.01                | 2.05                | 2.00                | 2.36                | 2.61                | 0.10  | 0.01    |
| Pancreas (g) | 4.01                | 4.02                | 4.56                | 4.88                | 4.96                | 4.98                | 0.12  | 0.42    |
| Bursa (g)    | 3.99                | 4.08                | 4.11                | 4.12                | 4.18                | 4.16                | 0.19  | 0.80    |

Results in cells containing various characters vary markedly ( $P < 0.05$ ); dressed weight (DW), dressed percent (DP) and standard error of mean (SEM) *Prosopis africana* oil (PAOs) was added to the diet in the following treatments:

T1: Control diet + 0% PAOs; T2: Basal diet + 2.0 g/kg Neomycin; T3: Baseline diet + 200 mg PAOs;

T4: Baseline diet + 400 mg PAOs; T5: Control diet + 600 mg PAOs; and T6: Basal diet + 800 mg PAOs.

### Nutrient retention of broiler chickens fed different levels of *Prosopis africana* oil

Table 4 reveals the effect of treatments on nutrient retention of broiler chicks. Dry matter retention was highest for T6 (85.22%), T5 (84.16%), T4 (82.80%), T3 (80.71%) and lowest for T1 (69.00%) ( $P < 0.05$ ). Crude protein retention was higher ( $P < 0.05$ ) for T3 (74.61%), T4 (75.12%), T5 (77.10%) and T6 (78.83%) than for T1 (60.81%) and T2 (67.10%). Fat retention was lower ( $P < 0.05$ ) for T1 and T2 than for other treatments. Crude fibre retention was highest ( $P < 0.05$ ) for T3, T4, T5 and T6 and lowest for T1 (38.40%). Ash values were

highest in T3, T4, T5 and T6 and lowest in T1 and T2 ( $P>0.05$ ). Nitrogen free extract retention was maximum ( $P<0.05$ ) for T6 (81.34%), T5 (80.25%), T4 (80.11%) and lowest for T3 (78.50%), T2 (72.15%) and T1 (70.22%) ( $P<0.05$ ).

The increased nutritional retention of birds receiving PAOs is consistent with earlier studies (Hernandez et al., 2004), which found that adding plant extracts to a diet increased the apparent whole-tissue digestibility of nutrients. This improvement may have resulted from the activation of digestive enzymes like saliva or bile acids as well as the action of digestive enzymes by PAOs, which increased the number of microbes in the colon. The physiological and chemical functioning of the gastrointestinal system may be impacted by isoprene derivatives, flavonoids and other plant metabolites. For instance, it has been noted that saponins increase the trypsin enzyme's activity, allowing for effective protein digestion.

The initial nutrition metabolism may be linked to the stabilizing effect on the gut bacteria (Mukesh et al., 2003). According to Basharat, (2018), essential oils have a laxative, spasmolytic and anti-flatulent action on the gastrointestinal tract. Increased digestive enzyme release improves digestion, the breakdown of metabolic waste products, as well as the absorption and metabolic conversion of the given feed nutrients (Basharat, 2018). In comparison to alternative treatments, *Prosopis africana* oil improved the digestion of nutrients in birds, improving the animals' overall health.

This research supports the findings of previous study in 2018, who found that broilers fed diets supplemented with 200 mg/kg of peppermint essential oil had higher crude protein digestibility. Improved feed conversion ratio is required for birds fed PAOs to have improved digestibility. Better muscle accretion occurs in broiler hens due to greater protein digestion (Christine, 2018). On the other hand, previous study in 2016 found that oregano oil inclusion in the meal at 800 mg/kg had no significant ( $P>0.05$ ) impact on nutritional absorption. According to previous study adding mixes of oregano, orange peel and chicory oil to broiler chicken diets at 0.4% did not improve nutrient digestibility. This variation could be explained by variations in dosage, location, as well as bioactive chemical or phytochemical variation.

**Table 4** Effect of feeding *Prosopis africana* oil on the nutrient retention of broiler chicks

| Parameters        | T1                 | T2                 | T3                 | T4                 | T5                 | T6                 | SEM  | P-value |
|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|------|---------|
| Dry matter (%)    | 69.00 <sup>c</sup> | 70.22 <sup>b</sup> | 80.71 <sup>a</sup> | 82.80 <sup>a</sup> | 84.16 <sup>a</sup> | 85.22 <sup>a</sup> | 5.67 | 0.34    |
| Crude protein (%) | 60.81 <sup>c</sup> | 67.10 <sup>b</sup> | 74.61 <sup>a</sup> | 75.12 <sup>a</sup> | 77.10 <sup>a</sup> | 78.83 <sup>a</sup> | 4.06 | 0.23    |
| Crude fibre (%)   | 38.40 <sup>b</sup> | 38.99 <sup>b</sup> | 40.81 <sup>a</sup> | 41.45 <sup>a</sup> | 42.72 <sup>a</sup> | 43.00 <sup>a</sup> | 2.25 | 0.14    |
| Ether extract (%) | 55.63 <sup>b</sup> | 58.10 <sup>b</sup> | 63.90 <sup>a</sup> | 65.16 <sup>a</sup> | 65.88 <sup>a</sup> | 66.93 <sup>a</sup> | 3.98 | 0.19    |
| Ash (%)           | 28.19 <sup>b</sup> | 28.84 <sup>b</sup> | 31.10 <sup>a</sup> | 33.85 <sup>a</sup> | 33.90 <sup>a</sup> | 33.97 <sup>a</sup> | 2.06 | 0.10    |
| NFE (%)           | 70.22 <sup>b</sup> | 72.15 <sup>b</sup> | 78.50 <sup>b</sup> | 80.11 <sup>a</sup> | 80.25 <sup>a</sup> | 81.34 <sup>a</sup> | 5.15 | 0.30    |

Values in cells with various characters vary markedly ( $P<0.05$ ); NFE stands for nitrogen-free extract and SEM for standard error of mean. T1: base diet plus 0% *Prosopis africana* oil; T2: base diet plus 2.0g/kg neomycin; T3: base diet plus 200 mg PAOs; T4: base diet plus 400 mg PAOs; T5: base diet plus 600 mg PAOs; T6: base diet plus 800 mg PAOs.

#### Effect of *Prosopis africana* oil on the oxidative stress of broiler chickens

Effect of *Prosopis africana* oil on the oxidative stress of broiler chickens is in (Table 5). Activities of malondialdehyde (MLAE), superoxide dismutase (SODE), catalase (CATE), reduced glutathione (GSHE) and glutathione peroxidase (GPE) ranged from 6.60 – 14.33 nmol/mL, 100.2 – 238.5 u/mL, 19.48 – 40.11 nmol/g, 5.05 – 9.74 ng/g and 6.21 – 11.44 ng/g respectively. MLA and GPx values were highest in T1; intermediate in T2 and lowest in T3, T4, T5 and T6 ( $P<0.05$ ) whereas SOD and GSH values were higher in T1 and T2 relative to the other treatments ( $P<0.05$ ). CAT value was higher ( $P<0.05$ ) in T3, T4, T5 and T6 than the rest of the treatments. Free radicals are highly reactive, short-lived molecules that can harm cells, including deoxyribo nucleic acid and cell membranes (Suman et al., 2021; Alagbe, 2019).

They are the byproducts of live cells' typical physiological processes (Suman et al., 2021). In the current study, feeding birds with PAOs resulted in considerably higher levels of hepatic antioxidant enzymes and lower levels of malondialdehyde (MDA) than other treatments ( $P<0.05$ ). Lin et al., (2016) noted that consumption of phytogetic feed additives caused an increase in serum antioxidant enzyme activities and a decrease in MDA content and they reported the same results. Similarly, plant extracts have been shown to boost antioxidant enzyme levels, prevent lipid peroxidation, and scavenge free radicals by Wachtel-Galor and Benzie, (2011).

On the other hand, previous study found that the addition of phytogetic feed ingredients had no impact on the level of blood glutathione. Oluwafemi et al., (2021) claim that *Prosopis africana* essential oil creates a range of antioxidant compounds to halt the oxidation of the venerable substrate. Birds can be protected against free radicals by the minerals and vitamins in PAOs, which also

function as antioxidants. Numerous physiological processes, such as growth, reproduction and immunity, have been shown to be negatively impacted by free radical and lipid peroxidation (Gladine et al., 2007; Alagbe and Grace, 2019).

**Table 5** Effect of *Prosopis africana* oil on the oxidative stress of broiler chickens

| Parameters    | T1                 | T2                 | T3                 | T4                 | T5                 | T6                 | SEM  | P-value |
|---------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|------|---------|
| MLA (nmol/mL) | 14.33 <sup>a</sup> | 10.95 <sup>b</sup> | 8.67 <sup>c</sup>  | 7.83 <sup>c</sup>  | 7.11 <sup>c</sup>  | 6.60 <sup>c</sup>  | 0.40 | 0.25    |
| SOD (u/mL)    | 100.2 <sup>b</sup> | 109.6 <sup>b</sup> | 113.0 <sup>b</sup> | 121.4 <sup>b</sup> | 204.6 <sup>a</sup> | 238.5 <sup>a</sup> | 3.20 | 0.001   |
| CAT (nmol/g)  | 17.48 <sup>c</sup> | 22.80 <sup>b</sup> | 30.80 <sup>a</sup> | 35.60 <sup>a</sup> | 35.85 <sup>a</sup> | 40.11 <sup>a</sup> | 0.55 | 0.13    |
| GSH (ng/g)    | 5.06 <sup>b</sup>  | 5.05 <sup>b</sup>  | 5.03 <sup>b</sup>  | 5.11 <sup>b</sup>  | 9.02 <sup>a</sup>  | 9.74 <sup>a</sup>  | 0.25 | 0.30    |
| GPx (ng/g)    | 6.21 <sup>c</sup>  | 7.00 <sup>c</sup>  | 7.07 <sup>c</sup>  | 8.56 <sup>c</sup>  | 10.64 <sup>b</sup> | 11.44 <sup>a</sup> | 0.32 | 0.11    |

Means within rows with different letters are significantly different ( $p < 0.05$ ); MLAE: malondialdehyde; SOD: Superoxide dismutase; CATE: Catalase; GSHE: Reduced glutathione; GPE: Glutathione peroxidase; SEM: Standard error of mean; T1: Basal diet + 0% *Prosopis africana* oil; T2: Basal diet + 2.0g/kg Neomycin; T3: Basal diet + 200 mg PAOs; T4: Basal diet + 400 mg PAOs; T5: Basal diet + 600 mg PAOs; T6: Basal diet + 800 mg PAOs

## 5. CONCLUSION

Ultimately, the experiment's finding showed that dietary supplementation of *Prosopis africana* essential oil (PAOs) did not have any adverse impacts on broiler chickens, such as bacterial resistance or harmful residual deposits in the system. Supplementing oil up to 800 mg/kg had a positive effect on growth performance, feed conversion ratio, immune system and higher carcass output. In order to reconcile the production of animals and the safety of food, PAOs can also be employed.

### Ethical compliance

The authors have followed ethical standards in conducting the research and preparing the manuscript.

### Informed consent

Not applicable.

### Ethical approval

The ethical guidelines for plants & animals are followed in the study.

### Conflicts of interests

The authors declare that there are no conflicts of interests.

### Funding

The study has not received any external funding.

### Data and materials availability

All data associated with this study are present in the paper.

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